DATA PROCESSING FOR THE SPACE-BASED DESIS HYPERSPECTRAL SENSOR

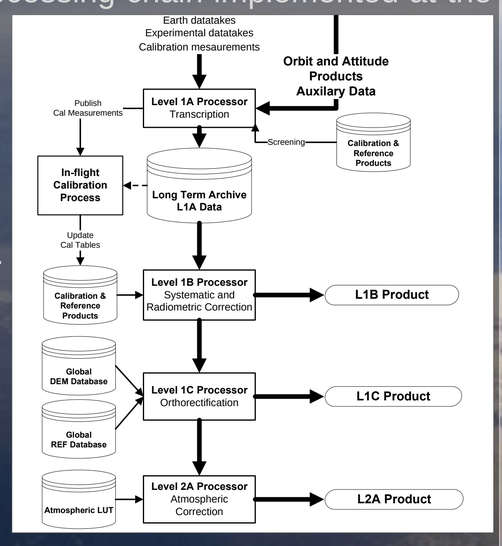
THE MUSES PLATFORM

DESIS is installed in the **Multi-User System for Earth Sensing (MUSES)** platform. MUSES is a precision Earth-pointing platform for remote sensing developed by **Teledyne Brown Engineering (TBE)** as a commercial venture for the **International Space Station (ISS)**. The MUSES platform provides accommodation for up to four instruments in four containers, two for large payloads (like DESIS) and two for small payloads.

DESIS DATA PROCESSING

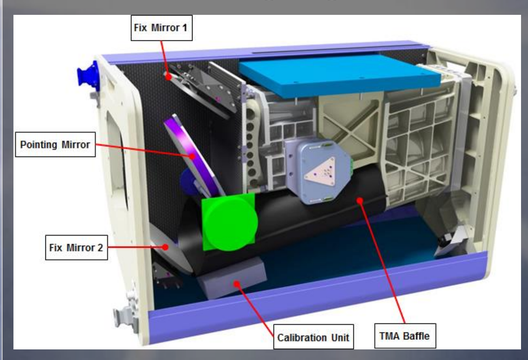
DESIS data products are defined as tiles of 1024×1024 pixels (~30×30 km^2) obtained from the tiling of data take strips over the Earth surface. The figure summarizes the DESIS processing chain and associated products. All products are generated by the same processors and processing chain implemented at the DLR and TBE Ground Segments (GSs).

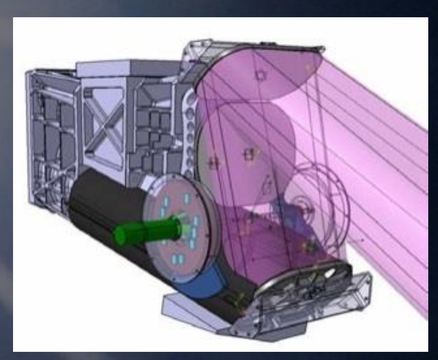
- **L1A** – Raw data with corresponding radiometric, spectral and geometric correction and calibration computed and appended, but not applied.
- **L1B** – Level 1A data not re-sampled, quality-controlled and radiometrically calibrated
- **L1C** – Level 1B data orthorectified, re-sampled to a specified grid
- **L2A** – Earth located pixel values converted to ground surface reflectance, i.e. after atmospheric corrections.



THE DESIS INSTRUMENT

DESIS (DLR Earth Sensing Imaging Spectrometer) is realized as a pushbroom imaging spectrometer sensitive in the **Visible-Near Infrared (VNIR)** spectral range (400–1000 nm). It can reach a spectral sampling distance of 2.55 nm with a GSD at Nadir of 30 m (400 km flight altitude). The shutter mechanism is electronically realized as a **Rolling Shutter (RS)**. A Pointing Unit allows to change the DESIS viewing angle

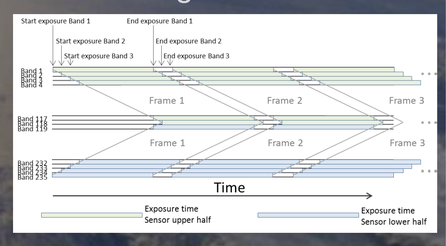




DESIS Instrument Design Parameters	
Telescope (F# / Focal Length)	3 / 320 mm, telecentric
FOV (IFOV)	4.4° (0.004°)
Swath @ Nadir	~30 km @ 400 km (ref. flight altitude)
Spectral Range	400 nm – 1000 nm
Spectral Sampling / num. channels	2.55 nm / 235 bands (no binning) (2× 3× and 4× binning available)
SNR @550nm	205 sampled for 2.55 nm (no binning)
Spatial Pixels	1024
Radiometric Linearity	> 95% (10%-90% FWC)
MTF @ Nyquist	< 3 nm
Off-nadir capability	± 15° along track by POI with 1° steps
Max. Frame rate	232 Hz
Pixel Quantization	12 bit + 1 bit for low/high gain setting
Pointing Unit	BRDF mode: 11 measurement positions ±15° (every 3°)

THE ROLLING SHUTTER EFFECT

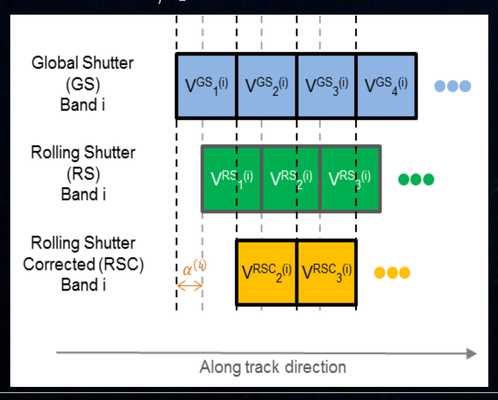
The RS mode used in DESIS introduces a sequential time shift of the exposure time of each spectral band. These time shifts and the movement of DESIS cause that the ground area captured by each band is displaced ~25 cm with respect to the previous band. The data cube obtained from a DESIS acquisition is not aligned to a common spatial grid on ground. In order to provide an image where the 235 bands (no-binning) are aligned, DESIS processing must include a step where all bands are resampled to the same spatial grid. This step is called **RS Correction (RSC)** and takes place in L1B processor.

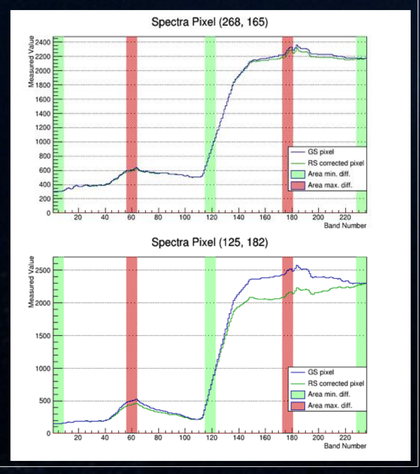


ROLLING SHUTTER CORRECTION

A simple linear interpolation RS correction is currently implemented as baseline correction. The **Correction Difference (CD)** is defined as the difference between the RSC values and the corresponding **Global Shutter (GS)** measurement. Simulations using data from other Hyperspectral instruments are used to simulate RS and GS DESIS data. The CD depends on the RS phase shift in each band. It is also maximum when sharp transitions are found in the across-track direction.

$$V^{RSC}{}_{j}^{(i)} = V^{RS}{}_{j-1}^{(i)} \times \alpha^{(i)} + V^{RS}{}_{j}^{(i)} \times \left(1 - \alpha^{(i)}\right)$$

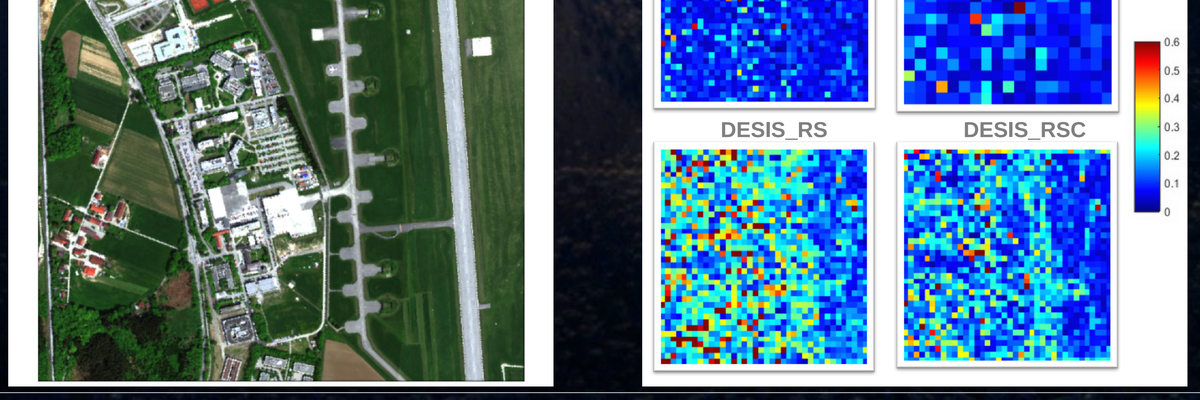




ROLLING SHUTTER AND SPECTRAL UNMIXING

First results on RSC are demonstrated using an airborne HySpex image. DESIS data are simulated from HySpex data in 4 different configurations: **GS30**, **GS60**, **RS** and **RSC** (see table). Results are shown in terms of **Root Mean Square Error (RMSE)** on the abundances as computed in these 4 cases with respect to the HySpex case.

Case	Parameters	RMSE
DESIS_GS30	30 m pixel, GS	0.10
DESIS_GS60	60 m pixel, GS	0.10
DESIS_RS	30 m pixel, NO RS correction	0.23
DESIS_RSC	30 m pixel, lin. interpol. correction (baseline)	0.17



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